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(54) AUTOMATIC CONTINUOUS METHOD AND APPARATUS FOR INSTANTANEOUS VACUUM VAPORISATION FOR THE RECOVERY OF USED SOLVENTS

(71) I, LOUIS SUSSMEYER, a Belgian Citizen, of 175 Avenue de Jette, 1090 Brussels, Belgium, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an automatic continuous method of and apparatus for instantaneous vacuum vaporisation for the recovery of used solvents.

Legal requirements for the protection of the environment prohibit the liberation into the biosphere of vast quantities of polluting solvents laden with chemical products, but industrialists do not always possess the complicated and expensive equipment necessary to recover the solvents and they are therefore compelled to have recourse to specialist agencies. The latter distil in bulk on a large scale the used solvents originating from a wide variety of sources. It inevitably follows that, between the fresh initial solvents of a particular source and the redistilled solvents, considerable differences in composition exist which are in danger of compromising the performance of work where precision is essential.

Consequently it is very much in the users interest to have a certain, reliable and easily operated recovery apparatus of their own for used solvents, so that they have at all times fresh solvents of well defined composition.

According to the automatic continuous method of instantaneous vacuum vaporisation for the recovery of used solvents according to the invention, a given volume of a heat carrier liquid, such as a light mineral oil, is heated in a first enclosure under reduced pressure by indirect thermal exchange with a heat exchange fluid, such as steam, the heat carrier liquid is circulated between the first enclosure and a second enclosure positioned above the first and subject to the same reduced pressure, used solvent is introduced by suction into the second enclosure, this suction being effected automatically as a function of the measured value of the reduced pressure in the enclosures and of the temperature of the heat carrier liquid, the used solvent is evaporated at the surface of the hot heat carrier liquid, the solvent vapour is condensed, the liquid thus recovered is pumped into a tank from where it flows by gravity to the exterior, and simultaneously the solids liberated by the vaporisation of the solvent are collected at the bottom of the first enclosure in the form of sludges containing the heat carrier liquid, the sludges are discharged constantly to the exterior by gravity without introducing air into the enclosure at a rate which depends upon the concentration and the flocculation power of the solids, the sludges are decanted and the recovered heat carrier liquid is reinjected by suction into the first enclosure, this operation being initiated automatically as soon as the level of heat carrier liquid in the first closure falls below a predetermined value.

A reduced pressure of 60 to 90 torr may be maintained in the enclosures and the heat carrier liquid may be heated to a temperature of 100 to 130°C.

The apparatus for performing the method according to the invention comprises a cylindrical boiler disposed horizontally, with a decantation hopper provided with a lock valve having a plug with a blind hole to discharge the vaporisation sludges by gravity without introducing air into the apparatus, and an evaporator of frustoconical shape adapted to vaporise the used solvent instantaneously, disposed horizontally above the boiler, bearing at its uppermost point a condenser, inclined downwards, the outlet of which is connected to the suction inlet of a vacuum pump whose outlet is adapted to deliver the condensate of the vaporisation into a tank from where it flows by gravity to the outside, the hopper, the boiler and the evaporator each being enveloped by a jacket through which a heat exchange fluid such as steam can be passed, the boiler,

which contains a heat carrier liquid such as a light mineral oil which can be heated by the heat exchange fluid, being equipped at its outer wall with an automatic level regulator, with a pipe connected to the suction inlet of a circulating pump and with a pipe connected to a pipe for recovered heat carrier liquid, the evaporator being connected at its lowest point to the boiler by a straight pipe and also connected to the delivery outlet of the circulating pump by a pipe to which there is connected a tube dipping into a tank of used solvent, the admission of the used solvent by suction into the evaporator being controlled by a temperature/pressure controlled valve operable in dependence upon the measured value of the reduced pressure in the evaporator and of the temperature of the heat carrier liquid, the boiler and the evaporator being connected to one another at their highest parts in order to equalise the pressure therein and each comprising at one end a large demountable inspection door which may have an illumination port, and at the other end, connecting means to a blade device, which device is adapted to scrape the interior walls, the walls being lined with an anti-adhesive material.

The plug with blind bore of the lock valve may be adapted to rotate automatically upon its axis, the rotation being driven by a pneumatic jack, a cam, a set of relays and an electric timer arranged so that the aperture of the blind hole is presented alternately towards the decantation hopper for filling, and a few moments later, towards the exterior for emptying of the solids, the movement of the plug being stopped by the cam at each passage through the dead centre or filling and being restarted by an electric timer, the frequency of action of which may be regulated as a function of the concentration of the solids and of their flocculating power.

The apparatus may further comprise, beneath the lock valve, a rotary tank or carousel mounted on wheels, guided at its centre by an axis embedded in the ground, fitted with metallic cages which may be provided with bags of jute or a similar porous material to receive the sludges, and means for re-injecting the heat carrier liquid recovered by filtration in the tank into the boiler by suction.

A pipe for the recovered heat carrier liquid, connected to the boiler, may dip into the tank and comprise an adjusting valve connected to the automatic level regulator which remains closed so long as the liquid level in the boiler is maintained at a predetermined value but which opens automatically when the level falls below that value and causes the recovered heat carrier liquid to be sucked from the tank into the boiler.

The scraper devices, with which both the evaporator and the boiler are fitted, may each comprise internal blades mounted crosswise on springs fixed to a horizontal shaft which can rotate between a rotary bearing and a fluid tight guide bearing, the two arms passing through the guide bearing on the same side of the apparatus, their adjacent ends each being engaged in a pawl mechanism mounted on an arm and the two arms being linked to the two ends of a common piston rod of a double acting pneumatic jack adapted to set the two shafts in rotation so that the blades exert upon the walls, which are lined with an anti-adhesive material, a light scraping which maintains them in a state of cleanliness.

The circulating pump, capable of feeding into the evaporator the hot heat carrier liquid necessary for the instantaneous vaporisation of used solvent, may be a pump of the open wheel centrifugal type rendered fluid tight by a mechanical stuffing, coupled directly to an explosion-proof electric motor provided with a cooling disc to avoid over heating.

The vacuum pump, which is intended to maintain the reduced pressure and to pump the condensate to the exteior, may be a pump of the liquid ring type, rendered fluid tight by a mechanical stuffing and mounted on a common plate with an explosion-proof motor.

The liquid ring of the pump may be formed and maintained by feeding the pump with a fraction of the condensate pumped to the exterior, this fraction, taken from a first cooler called the primary exchanger and cooled in a second cooler called the secondary exchanger, being sucked by the pump through the coil of the latter exchanger.

The condenser may be of the type with a bank of tubes cooled by water circulation, the front part of the evaporator being closed at the top by an explosion disc, and connected to the outlet of the evaporator, while the rear part of the evaporator constitutes a condensate reception chamber, this condensate being passed to the inlet of the vacuum pump by a pipe system, a part of the circulating water coming from the coil type primary exchanger and the balance being fed automatically to the water inlet by a thermostatic valve, the sensitive bulb of which is located at the water outlet.

A specific embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which:—

Fig. 1 is a partial view in elevation of an apparatus according to the invention;

Figs. 2 and 3 are partial front and rear views of the apparatus of Fig. 1;

Fig. 4 is a partial schematic view of a

continuous device for decanting the traces of water which may be contained in the distillate and for collecting the water free distillate;

Fig. 5 is a partial schematic view of a continuous device for discharging solids and recycling heat carrier liquid, and

Fig. 6 is a schematic and partial view of a continuous scraping device for the enclosures.

As illustrated in the drawings, a heat carrier liquid 10 (Fig. 5) such as a light mineral oil is introduced into a cylindrical boiler 11 (Figs. 1 and 5) disposed horizontally on legs 12 resting on the ground. The lower part of the boiler 11 has a decantation hopper 13 provided with a lock valve 14. An evaporator 15 of frustoconical shape is secured horizontally above the boiler by a straight pipe 16 with flanges so as to connect vertically the lowest point of the evaporator to the upper part of the boiler. A condenser 17, advantageously of the type with a bank of tubes, is secured by a flanged pipe 18 at its inlet to the uppermost point of the evaporator so that the outlet of the condenser is positioned lower than the inlet.

The boiler 11, the hopper 13 and the evaporator 15 are enveloped respectively by a cylindrical jacket 11^1 and frustoconical jackets 13^1 and 15^1, through which a heat exchange fluid 19 (Fig. 2), advantageously steam, can be passed, being admitted through an adjustable valve 20 and fed through an appropriate pipe 21. The steam makes it possible to heat the heat carrier liquid 10 present in the boiler approximately to between 100 and 130°C.

The domed end walls of the boiler and of the evaporator, and so far as possible all the pipes connecting the various parts of the apparatus, are fitted with flanges to facilitate demounting and maintenance. The front domed walls 22 and 23 (Figs. 1 to 3) of the boiler and of the evaporator each constitute a large inspection door, and that of the evaporator comprises two windows 24 and an illumination port 25. The rear walls 26 and 27 of the boiler and of the evaporator are joined at their upper part by two balance pipes 28 (Figs. 1 and 3), one of which is shown broken away for clarity in Fig. 1, these pipes being intended to maintain the same pressure in these enclosures.

To a tube 29 fitted into the base of the rear wall 26 of the boiler, is connected the suction inlet of a centrifugal pump 30, of the open wheel type, coupled directly to an explosion-proof electric motor 31. The delivery outlet of this pump is connected to the bottom of the rear wall 27 of evaporator by a pipe 32; a part of the heat carrier liquid can thus be transferred from the boiler to the evaporator so that a circulation current can be established through the intermediary of the straight pipe 16 joining the two enclosures.

The condenser 17, equipped in its upper part with an explosion-disc 33 and provided with tubes 34, 35 respectively for the inlet and the outlet of cooling water, comprises at its lower part a distillate reception chamber 36 which is connected, by a pipe 37, to the suction inlet 38 (Fig. 4) of a liquid ring type vacuum pump 39 mounted conjointly on a common plate 40 with an explosion-proof electric motor 41. This vacuum pump is capable of creating and maintaining at reduced, i.e. sub-atmospheric, pressure of from 60 to 90 torr approximately in the apparatus.

The pipe 32 (Figs. 1 and 3) which serves to convey the heated heat carrier fluid, carries a tube 42 to which there is connected a flexible hose 43 which dips into a tank 44 filled with used solvent. The hose 43 is equipped, close to the tube 42, with a temperature/pressure controlled valve 45 capable of regulating the flow rate of used solvent sucked into the evaporator; the control parameters affecting the operation of the valve 45 are the temperature of the heat carrier liquid and the reduced pressure prevailing in the apparatus.

The principle of the method of the invention can now be visualised, the interconnected enclosures 11, 13, 15 and 17 being placed under reduced pressure by the vacuum pump 39, the heat carrier liquid 10 being heated by the steam 19 and the centrifugal pump 30 circulating the liquid between the boiler and the evaporator. The used solvent sucked up from the tank 44 is injected into the heat carrier liquid and evaporates instantaneously. The solvent vapour reaches the condenser 17 through the straight pipe 18, is cooled in contact with the water-cooled tubes and condenses. A current of distillate commences in the distillate chamber 36 and flows through the pipe 37 to the suction inlet 38 of the vacuum pump 39.

The distillate 46 or 47 (Fig. 4) may be lighter or heavier than water; it may be constituted by a single solvent or by a mixture of solvents, and it may contain traces of water 48. It is delivered by the outlet 49 of the pump 39 to a water separator 50, which is of the gravity decantation type. This essential element is capable of functioning with all liquids which are not miscible with water and which have a different density from water; it is constituted by a cylinder 51 closed at both ends 52, 53 and slightly inclined with respect to the horizontal.

The distillate is passed from the pump outlet 49 through a pipeline 54 to a junction 55, the vertical branch 56 of which discharges the air to the upper part of a cooler

called the primary exchanger 57; the air thus delivered is able to escape through a vent 58. The horizontal branch 59 of the junction delivers the distillate to an inlet 60 provided in the upper part of the lower end 52 of the cylinder 51.

If the traces of water 48 are heavier than the solvent, they tend to descend and to accumulate at the lowest point 61 of the end 52, where they are discharged by gravity into a receptacle 62; the water is drawn off through a valve 63 and the solvent is passed through a pipeline 64 to the highest point 65 of the upper end 53 of the cylinder 51.

Conversely, if the traces of water are lighter than the solvent, they tend to rise towards the highest point 65 and to be passed conversely towards the receptacle 66. The water is discharged to the exterior by overflowing at the valve 67 of the receptacle 66 and the heavier solvent reaches the cylinder 51 through the pipeline 68.

As a safety measure, and to prevent the formation of an air pocket in the upper part of the cylinder 51, a branch 69 is provided at the upper part of the connecting pipeline 64, which permits the air to be discharged to the top of the primary exchanger 57. The distillate 46^1 or 47^1, lighter or heavier than air, freed from traces of water, leaves the cylinder 51 through a pipeline 70, enters tangentially the upper part 71 of the primary exchanger 57 and is cooled against a coil 72 whilst descending towards the outlet 73 of the latter. The outlet 73 communicates on the one hand with an overflow 74 from where the solvent is discharged into a tank 75 open to atmospheric pressure, and on the other hand with the air vent 58, to prevent any siphoning.

The coil 72 of the primary exchanger is provided with feed water by a pipe 76, which first of all cools the coil 77 of a second cooler 78 called the secondary exchanger. The coil 77 is connected to the base of the primary exchanger and to an inlet 38^1 of the vacuum pump 39, so that a fraction of the solvent or mixture of solvents 46^1 or 47^1, free from water, taken from the primary exchanger, can be strongly cooled and can feed the liquid ring of the pump whilst reducing to a maximum the vapour pressure of the solvent, which improves the efficiency of the pump.

The secondary exchanger 78 also assists in reducing to a minimum the total quantity of feed water necessary to perform all the cooling operations of the process, which is introduced through the pipeline 76. To this end, the water leaving the coil of the primary exchanger is passed to the inlet 34 of the condenser; the balance of the cooling water necessary to cool the tubes of the condenser is fed automatically to the inlet 34 through a thermostatic valve, not shown in the drawings, the sensitive bulb of which is immersed in the outlet 35.

It is clear from the above description that the method can only be performed continuously if the controlled valve 45, fitted to the inlet to the evaporator, effectively regulates the rate of admission of used solvent as a function of the variations of the temperatures of the heat carrier liquid (approximately 100 to 130°C) and of the reduced pressure prevailing in the apparatus (approximately 60 to 90 torr), variations which incidentally correspond *inter alia* to variations in the composition of the used solvent, to a decrease in the temperature which occurs when the used solvent, present at ambient temperature, spreads on the surface of the heat carrier liquid, and to a temperature reduction representing the heat of evaporation of the solvents, etc. It is self-evident that the evaporation liberates the substances initially held in solution by the solvents and that these substances disperse within the heat carrier liquid: if their concentration increased constantly the system would exceed the above stated limits, the adjusting valve 45 would cease to function and the admission of solvent would cease.

Means have therefore been provided to discharge these essentially solid substances in an automatic and continuous manner.

To prevent these solid residues from forming an insulating layer on the interior walls of the boiler and of the evaporator, they are coated with an anti-adhesive product, advantageously with Teflon (Registered Trade Mark), forming respective linings 11*a* and 15*a* (Figs. 5 and 6) so that the residues do not adhere but are deposited simply by decantation. A series of blades or scrapers 79 are mounted on springs 80 fixed crosswise on a horizontal shaft 81. One end 82 of each shaft is adapted to rotate in an interior rotation bearing 83 fixed to the interior of the large door 22, 23 of the boiler or of the evaporator, respectively, and the shaft, passing through the opposite wall 26, 27, respectively, is adapted to rotate in a guide bearing 84 equipped with a mechanical stuffing 85 to produce fluid tightness of the apparatus. The end 86 of the shaft, emerging from the wall 27 of the evaporator, is of square section and is engaged in the toothed wheel 87 of a pawl mechanism 88 mounted on a disc 89 (Figs. 3 and 6) integral with a lever arm 90 fixed by its end 91 (Fig. 3) to the upper part 92 of a common piston rod 92—92^1 of a double acting pneumatic jack 93, the lower part 92^1 of the common rod being fixed to the end 91^1 of a lever arm 90^1 integral with a disc 89^1 on which a pawl mechanism identical to the first is mounted; the reciprocating

that the used solvent is admitted only if the vacuum and temperature conditions have jointly attained their respective values.

In a place adjacent to that where the apparatus is sited, free of solvent vapour risk, is placed a second control panel which comprises the following elements:

— a set of fuses per circuit;
— a contactor motor;
— a protection circuit with solenoid valves which shut off the heating steam and the inlet of the used solvent as soon as a motor stops and the timing of the lock valve;
— a set of two timers, one of which regulates the discharge frequency of the distillation residues and the other the time presumed to discharge the residues in suspension. This latter timer, if it is fitted for automatic functioning, can completely stop the operations of the apparatus, but in this case it is appropriate to equip the evaporator with a foam height detector, comprising for example a photoelectric cell, capable of stopping the heating and of admitting into the evaporator an inert gas adapted to reduce the foam.

On the other hand, as regards the evacuation of the apparatus at the commencement of the operations of the method, it should be observed that it is necessary to prime the vacuum pump 39 by introducing fresh solvent into it through the inlet 110, comprising a valve and a funnel, fitted to the primary exchanger 57.

Obviously the invention is not limited to the embodiment which has been described and illustrated by way of example and its ambit would not be escaped by making modifications to them within the scope of the appended Claims.

WHAT I CLAIM IS:—

1. An automatic continuous method of instantaneous vacuum vaporisation for the recovery of used solvents, wherein a given volume of a heat carrier liquid is heated in a first enclosure under reduced pressure by indirect thermal exchange using a heat exchange fluid, the heat carrier liquid is circulated between the first enclosure and a second enclosure placed above the first and subject to the same reduced pressure, used solvent is introduced by suction into the second enclosure, this suction being effected automatically as a function of the measured value of the reduced pressure in the enclosures and of the temperature of the heat carrier liquid, the used solvent is evaporated at the surface of the hot heat carrier liquid, the solvent vapour is condensed, the liquid thus recovered is pumped into a tank from where it flows by gravity to the exterior and, simultaneously, the solids liberated by the vaporisation of the solvent are collected at the bottom of the first enclosure in the form of sludges containing heat carrier liquid, the sludges are discharged to the exterior by gravity without introducing air into the enclosures at a rate which depends upon the concentration and upon the flocculating power of the solids, the sludges are decanted and the recovered heat carrier liquid is reinjected by suction into the first enclosure, this operation being initiated automatically as soon as the level of heat carrier liquid in the first enclosure falls below a predetermined value.

2. A method according to Claim 1, wherein the heat carrier liquid is a light mineral oil.

3. A method according to Claim 1 or Claim 2, wherein the heat exchange fluid is steam.

4. A method according to any one of the preceding Claims, wherein a reduced pressure from 60 to 90 torr is maintained in the enclosures.

5. A method according to any one of the preceding Claims, wherein the heat carrier liquid is heated to a temperature of 100 to 130°C.

6. Apparatus for performing the method according to Claim 1, comprising a cylindrical boiler disposed horizontally with a decantation hopper provided with a lock valve having a plug with a blind hole to discharge the vaporisation sludges by gravity without introducing air into the apparatus, and an evaporator of frustoconical shape adapted to vaporise the used solvent instantaneously, disposed horizontally above the boiler, bearing at its uppermost point a condenser inclined downwards, the outlet of which is connected to the suction inlet of a vacuum pump whose outlet is adapted to deliver the condensate of the vaporisation to a tank from where it flows by gravity to the exterior, the hopper, the boiler and the evaporator each being enveloped by a jacket through which a heat exchange fluid can be passed, the boiler, which contains a heat carrier liquid which can be heated by the heat exchange fluid, being equipped at its outer wall with an automatic level regulator, with a tube connected to the suction inlet of a circulating pump and with a tube connected to a pipeline for recovered heat carrier liquid, the evaporator, being connected at its lowest point to the boiler by a straight pipe and further connected to the delivery outlet of the circulating pump by a pipe to which a tube dipping into a tank of used solvent is connected, the admission of the used solvent by suction into the

movement of the piston and the pawl mechanism are able to set the two shafts 81 in rotation so that the blades 79 exert upon the walls, which are lined with anti-adhesive material, a gentle scraping which detaches the residues deposited upon the walls of the evaporator and of the boiler.

The residues fall into the decantation hopper 13 (Figs. 1, 2, 5) at a rate which depends upon their concentration and upon their flocculating power. The hopper carries at its base a lock valve 14, the plug 94 of which, of large diameter, comprises a blind hole 94^1 with a capacity of approximately 1 litre, so that the passage through the cock is obstructed on one side.

The horizontal shaft 95 of the plug is connected by a crank 96 to a pneumatic jack 97 controlled by a cam, a set of relays and an electric timer, not shown. These elements are arranged so that the plug is able to rotate about its axis and to present the aperture of the blind hole alternately towards the decantation hopper to fill it, and a few moments later, towards the exterior to empty it. The movement of the plug is stopped by the cam at each passage through the dead centre or filling point, and set in motion again by the electric timer, the frequency of action is regulated, after a few trials, as a function of the concentration of the residues and of their flocculating power.

As may be understood, the method according to the invention permits the residues to be discharged without affecting the value of the reduced pressure which prevails in the enclosures. However these residues are naturally mixed in variable quantity with heat carrier liquid, and it is desirable to return the latter into the boiler in order to maintain the distillation rate of the evaporator.

To this end, the residues 98 (Figs. 1, 2, 5) are pdropped into jute bags 99 which line a plurality of metallic cages 100, advantageously perforated, incorporated in a fitment 101 attached to a cylindrical tank 102 mounted on wheels 103 and guided in its centre by a shaft 104 embedded in the ground. By manually rotating this rotary assembly or carousel, each of the jute bags can be presented successively below the discharge of the lock valve; the heat carrier liquid flows from the bag into the tank and the bag can be discarded when it is full.

On the other hand, the boiler comprises in its lateral wall an automatic level regulator 105 (Figs. 2 and 5) associated with an adjusting valve 106 inserted into a pipeline 107, the upper end 108 of which is connected to the boiler while its lower end 109 dips into the tank 102; advantageously, the lower part of the pipeline 107 is a flexible tube. It is clear that the adjusting valve 106 remains closed so long as the level of heat carrier liquid is maintained at a predetermined value, but that it opens progressively if the level falls below that value and causes the heat carrier liquid 10 to be sucked into the boiler 11 from the tank 102.

It follows that the method according to the invention makes it possible, not only to discharge the solids liberated by the vaporisation, but also to recover the heat carrier liquid accompanying the solids, and this is an automatic continuous manner without breaking the vacuum.

Furthermore, it is self-evident that any installation in which inflammable solvents are treated must be protected against risk of explosion and fire. These risks are reduced here to a minimum by the fact that electricity is used only for any illumination which may be required and to supply the explosion-proof motors of the two pumps. The movements of all the other moving parts are effected in a simple and flexible manner by compressed air. Without entering into details, it may be noted that the apparatus may comprise, besides push buttons of the mushroom-type incorporated in a first control panel, the following other accessories and pneumatic appliances:

— an indicating thermometer to take the temperature of the heat carrier liquid;
— an indicating thermometer to take the water outlet temperature of the tubular condenser;
— manometers to control the cooling water, the compressed air, the steam, and the degree of vacuum prevailing in the installation enclosure;
— three pneumatic regulators, of which two are for regulating the temperature of the heat carrier liquid and the admision of the used solvent, and the third to control the first two as a function of the vacuum; and
— seven sets of expansion pressure regulators with a manometer for the circuits

(a) of the pneumatic jack 97 of the lock valve 14;
(b) of the pneumatic jack 93 of the scraper system 79;
(c) of the steam admission adjusting valve 20;
(d) of the solvent admission adjusting valve 45;
(e) of the heat carrier fluid admission adjusting valve 106; and
(f) regulating the vacuum.

The temperature regulator which controls the heating circuit is entirely independent. On the other hand, the second temperature regulator, which is identical, operates in combination with the vacuum regulator, so

evaporator being controlled by a temperature/pressure controlled valve operable in dependence upon the measured value of the reduced pressure in the evaporator and of the temperature of the heat carrier liquid, the boiler and the evaporator being connected to one another at their upper parts to equalise the pressures theirin and each comprising at one end a large demountable inspection door which may have an illumination port, and at the other end, connecting means to a blade device, which device is adapted to scrape the interior walls, the walls being lined with an anti-adhesive material.

7. Apparatus according to Claim 6, wherein the heat exchange fluid is steam.

8. Apparatus according to Claim 6 or Claim 7, wherein the heat carrier liquid is a light mineral oil.

9. Apparatus according to any one of Claims 6 to 8, wherein the plug with blind hole of the lock valve is adapted to rotate automatically on its axis, the rotation being driven by a pneumatic jack, a cam, a set of relays and an electric timer arranged so that the aperture of the blind hole is presented alternately towards the decantation hopper for filling and, a few moments later, towards the exterior for the emptying of the solids, the movement of the plug being stopped by the cam at each passage through the dead centre or filling position and being reset in motion by an electric timer, the frequency of action of which may be regulated as a function of the concentration of the solids and of their flocculating power.

10. Apparatus according to Claim 9, comprising beneath the lock valve, a rotary tank or carousel mounted on wheels, guided in its centre by an axis embedded in the ground, equipped with metallic baskets which may be provided with bags of jute or a similar porous material to receive the sludges, and means for re-injecting the heat carrier liquid collected by filtration in the tank into the boiler by suction.

11. Apparatus according to Claim 10, wherein a pipeline for the recovered heat carrier liquid, connected to the boiler, dips into the tank and comprises an adjusting valve connected to the automatic level regulator, which remains closed so long as the liquid level in the boiler is maintained at a predetermined value, but which opens automatically when the level falls below that value and causes the recovered heat carrier liquid to be sucked into the boiler from the tank.

12. Apparatus acocrding to any one of Claims 6 to 11, wherein the scraper devices, with which both the evaporator and the boiler are equipped, each comprise internal blades mounted cross-wise on springs fixed to a horizontal shaft which can rotate between a rotation bearing and a fluid tight guide bearing, the two shafts passing through the said guide bearings on the same side of the apparatus, their adjacent ends each being engaged in a pawl mechanism mounted on an arm and the two arms being linked to the two ends of a common piston rod of a double acting pneumatic jack adapted to set the two shafts in rotation, so that the blades exert upon the walls, which are lined with an anti-adhesive material, a light scraping which maintains them in a state of cleanliness.

13. Apparatus according to any one of Claims 6 to 12, wherein the circulating pump capable of feeding into the evaporator the hot heat carrier liquid necessary for the instantaneous vaporisation of used solvent is a pump of the open wheel centrifugal type, rendered fluid tight by a mechanical stuffing, coupled directly to an explosion-proof electric motor provided with a cooling disc to prevent over-heating.

14. Apparatus according to any one of Claims 6 to 13, wherein the vacuum pump, which is intended to maintain the reduced pressure and deliver the condensate to the exterior, is a pump of the liquid ring type, rendered fluid tight by a mechanical stuffing and mounted on a common plate with an explosion-proof motor.

15. Apparatus according to Claim 14, wherein the liquid ring of the pump is formed and maintained by feeding the pump with a fraction of the condensate delivered to the exterior, this fraction, drawn from a first cooler called a primary exchanger and cooled in a second cooler called a secondary exchanger, being sucked by the pump through the coil of the latter exchanger.

16. Apparatus according to Claim 15, wherein the condenser is of the type with a bank of tubes cooled by water circulation, the front part of the evaporator being closed towards the top by an explosion disc and connected to the outlet of the evaporator, while the rear part of the evaporator constitutes a condensate reception chamber, the condensate being directed to the inlet of the vacuum pump through a pipeline, a part of the circulating water coming from the primary exchanger with coil and the balance being fed automatically to the water inlet by a thermostatic valve, the sensitive bulb of which is positioned at the water outlet.

17. An automatic continuous method of instantaneous vacuum vaporisation for the recovery of used solvent, substantially as hereinbefore described with reference to the accompanying drawings.

18. Apparatus for performing the method according to any one of Claims 1 to 5 and 17, substantially as hereinbefore described and illustrated in the accompanying drawings.

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1476697 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

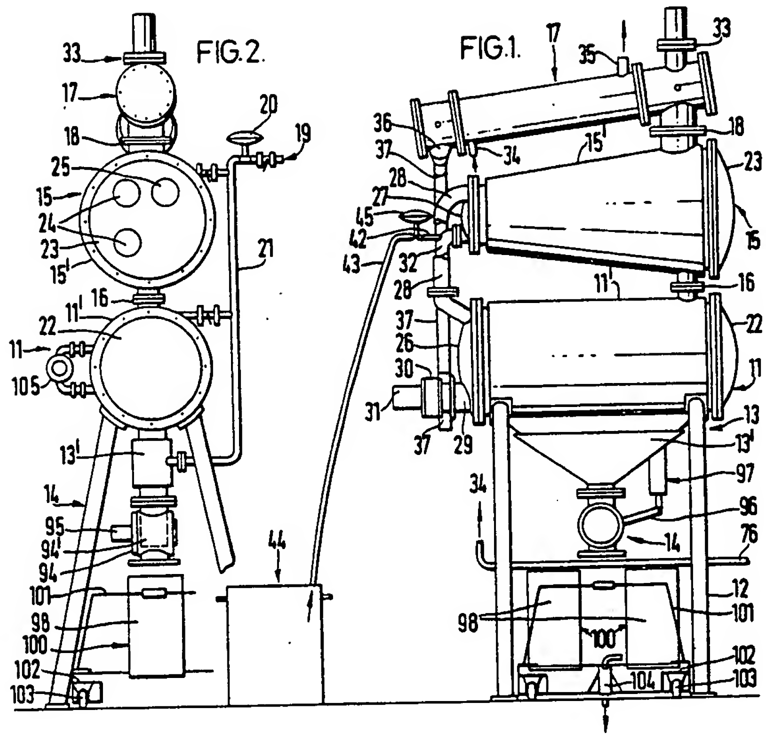

FIG.2.

FIG.1.

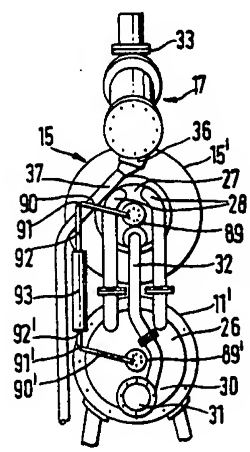

FIG. 3.

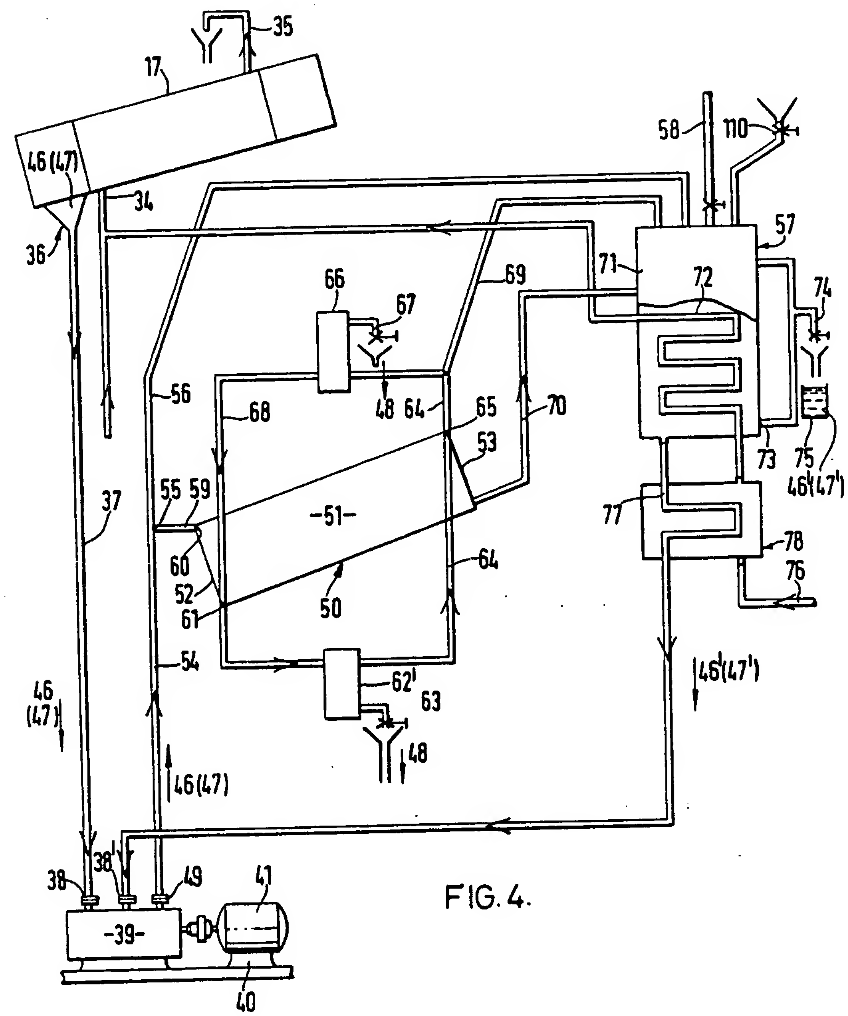
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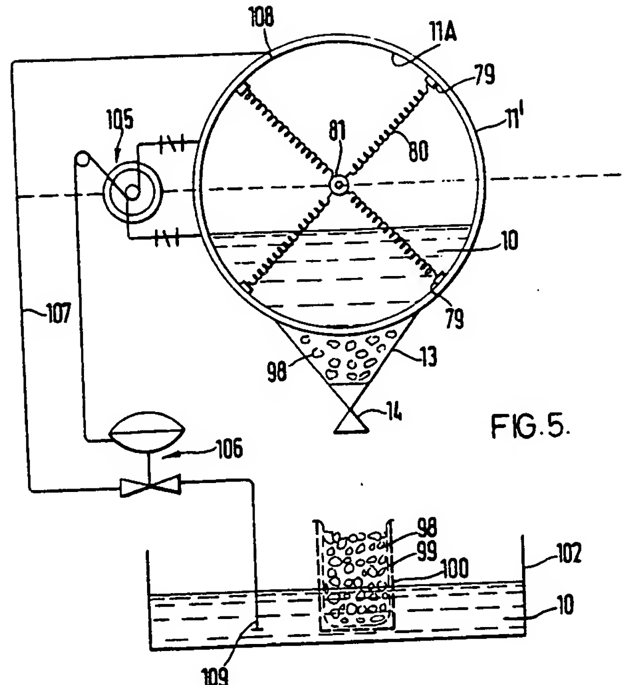
FIG. 4.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106
98
99
100
102
10
109

FIG.5.

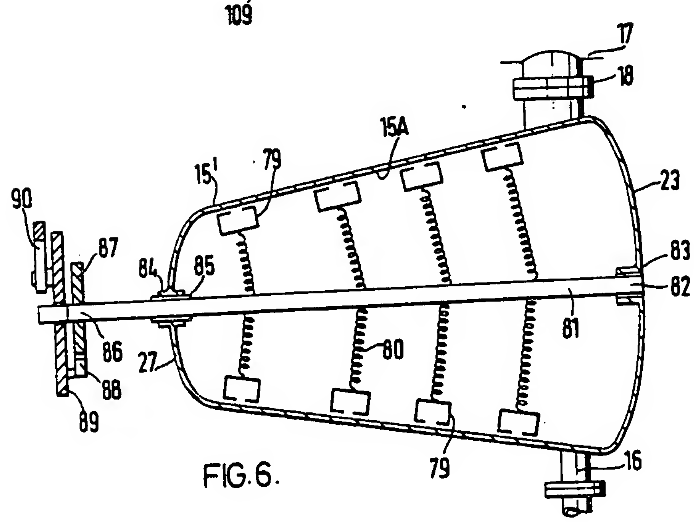
17
18
15A
79
15'
23
90
87
84
85
83
82
81
86
27
80
88
89
79
16

FIG.6.